INDOOR AIR QUALITY ASSESSMENT

Lincoln Elementary School
76 Lincoln Street
Northborough, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of the Northborough School Department and a parent, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality issues at the Lincoln Elementary School, 76 Lincoln Street, Northborough, MA. On October 4, 2000, a visit was made to this school by Cory Holmes, Environmental Analyst, Emergency Response/Indoor Air Quality (ER/IAQ), BEHA and Suzan Donahue, Research Assistant, BEHA, to conduct an indoor air quality assessment. John Conly, Head Custodian for Lincoln Elementary School, accompanied BEHA staff for portions of the inspection.

The school is a one-story, brick structure constructed in 1965 and houses kindergarten through grade 5 students. The school, divided into an upper wing and a lower wing, consists of general classrooms, library, cafeteria, computer room and office space. Windows are openable throughout the building. There is a central courtyard, which provides windows to interior classrooms.

Methods

Air tests for carbon dioxide were taken with the Telaire, Carbon Dioxide Monitor and the TSI, Q-Trak, IAQ Monitor, Model 8551. Tests for temperature and relative humidity were taken with a Mannix, TH Pen PTH 8708 Thermo-Hygrometer and the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

This school has a student population of 335 and a staff of approximately 50. The tests were taken during normal operations. Because the assessment occurred on an unusually warm day for October (outside temperature 78º), windows in most of the classrooms were found open. Since open windows can greatly contribute to reduction of carbon dioxide levels, two rounds of air testing were conducted throughout the building. In the morning, testing was conducted under normal operating conditions, however most classroom windows were open. Prior to the school lunch break, school staff required that all faculty members close classroom windows for a second round of air testing in the afternoon. Test results appear in Tables 1-9.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million of air (ppm) in twelve of twenty-eight areas surveyed in the morning, and in all classrooms (except room 17) in the afternoon, which indicates an overall ventilation problem in the school. As previously noted, windows and/or exterior doors were open in most rooms in the morning, which can greatly contribute to reduced carbon dioxide levels. Of note were the interior (courtyard facing) rooms, which had carbon dioxide measurements above 800 ppm with windows open.

Fresh air in classrooms is supplied by a unit ventilator (univent) system (see Picture 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building (see Picture 2) and return air through an air intake located at

the base of each unit (see Figure 1). Fresh air and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. All univents were capable of operating at the time of the assessment, however a number were deactivated. Univents are not controlled locally, but by a control panel located in the main hallway (see Picture 3). Each power switch controls the operation of 2-3 classroom univents. It was reported to BEHA staff that building occupants often deactivate univents via the control panel when they experience temperature extremes in a given classroom. Unfortunately this results in the deactivation of adjoining classroom ventilation equipment.

Obstructions to airflow such as books, papers and other items on top of univents, and bookcases, tables and file cabinets in front of univent return vents, were seen in a number of classrooms. To function as designed, univent air diffusers and return vents must remain free of obstructions. More importantly, the units must be activated and allowed to operate while the building is occupied.

Two separate exhaust systems exist in the school. The exhaust ventilation is provided by unit exhaust ventilators in most areas (see Picture 4). None of these units were operating during the assessment. It was reported that exhaust ventilators had not functioned for years. A second exhaust ventilation system exists within coat closets in each classroom. This second system is a ducted system, with the return grille located in the ceiling of the coat closets (see Picture 5). Classroom air is drawn into the coat closet from the classroom via undercut closet doors (see Picture 6). These vents were designed to remove moisture/odors from the closets and do not appear to be designed to serve as the main classroom exhaust vents. This exhaust system was operational but no draw of

air was noted in a number of rooms. Mr. Conly determined that the control switch controlling the exhaust fans in the team room (lower wing) was likely deactivated by building occupants. Mr. Conly reactivated the vents and BEHA staff verified draw of air through exhaust vents. The location of these closet vents allows them to be easily blocked by stored materials. In order to function properly, these vents must remain free of obstructions.

Former locker rooms were converted into the computer room and library. Fresh air intakes of univents in these rooms are located on the roof. Ductwork connects the fresh air intake to each unit. The exhaust vent for the computer room was located in a corner behind a shower partition (see Picture 7). Without adequate exhaust ventilation, excess heat and environmental pollutants generated by computer equipment can build up and lead to indoor air complaints. To provide comfort in these areas, wall-mounted fans were installed and are utilized as needed.

Poor air quality complaints were also expressed in the gymnasium and in the athletic director's office. The athletic director's office does not have supply or exhaust ventilation. The ventilation system in the gym should be activated during periods of occupancy.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings at the school were above the BEHA comfort range in many areas. Temperature readings in the school ranged from 73^{o} F to 81^{o} F in the morning air

testing with windows open. (The outside temperature was 78 ^{o} F.) School temperatures increased to a range of 78 ^{o} F to 84 ^{o} F with closed windows. (Outside temperature decreased to 73 ^{o} F.) The increased temperature range in the afternoon can also indicate inadequate airflow provided by the mechanical ventilation system. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F and 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with adequate fresh air supply.

As can be seen from the tables, many classrooms were above the BEHA comfort range. A number of temperature control complaints were expressed to BEHA staff during the assessment. This may indicate that thermostats are malfunctioning and may need re-calibration/replacement. In addition, temperature control is difficult without a properly functioning ventilation system.

The relative humidity in the building ranged from 26 to 43 percent in the morning, and a range of 35 to 54 percent in the afternoon. The majority of areas sampled were within the BEHA recommended comfort range. The BEHA recommends a comfort range of 40-60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Plants were noted in several classrooms. In classroom 3, a flowering plant was observed near the univent air diffusers. Plants should be located away from univents to prevent the aerosolization of dirt, pollen or mold. Also, moistened plant soil, drip pans and standing water can serve as sources of mold growth. All plants should be equipped with drip pans and over watering should be avoided.

Several classrooms had water-stained ceiling tiles, which are evidence of historic roof or plumbing leaks (see Picture 8). Water-damaged ceiling tiles can provide a source of mold and mildew and should be replaced after a water leak is discovered and repaired. No recent water damage was reported by building occupants.

Many classrooms had spaces around the sink countertop and splashboard. Improper drainage or overflow could lead to water penetration of countertop wood and potential damage to the cabinet interior. Below sink cabinets were used for storage of many paper/cloth items, some of which were water damaged. Water-damaged wood, paper, cloth and/or other porous items can provide a potential source of mold growth. Aquariums were noted in classrooms 9, 12 and in the upper wing hallway. Aquariums must be properly maintained to prevent bacterial and algae growth.

Other Concerns

A number of other conditions that can potentially affect indoor air quality were also observed. The metal deck above the stage area in the cafeteria has peeling paint (see Picture 9). If this paint is a latex or related product, this peeling paint can indicate that the metal surface was not primed appropriately. Without primer, the coat of paint cannot form a seal with the metal, resulting in peeling. If this paint was applied prior to 1980, it

is possible that it may contain lead. Lead containing paint can be a hazard to small children. Lead paint is required to be removed from residences with children six years old and under. While the lead paint is not required by Massachusetts statute to be removed in non-residential buildings, prudent public health practice would be to remediate peeling lead paint, particularly if students aged six years and under have access to the stage area.

Several classrooms contained dry erase boards and dry erase board markers. The art room contained permanent ink markers, which can contain toluene. Materials such as dry erase board cleaners contain methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999). All of these materials contain volatile organic compounds (VOCs), which can be irritating to the eyes, nose and throat.

Cleaning products were found on countertops and beneath sinks in a number of classrooms. Cleaning products contain chemicals (such as bleach or ammonia related compounds), which can be irritating to the eyes, nose and throat and should be stored properly out of reach of students. In addition, a number of classrooms contained unlabeled spray bottles. Products should be kept in their original containers or should be clearly labeled as to their contents for identification purposes, in the event of an emergency.

A number of photocopiers were noted in the building. The teacher's workroom also contained a lamination machine. Lamination machines give off odors. Volatile organic compounds (VOCs) and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). These machines also produce waste heat. Occupants should ensure local

exhaust ventilation is activated while this equipment is in use to help reduce odors, pollutants, and excess heat in the workroom.

Also of note was the amount of materials stored inside classrooms (see Picture 10). Items were seen piled on windowsills, tabletops, counters, bookcases and desks in classrooms throughout the school. The large amount of items stored allows for dusts and dirt to accumulate. These stored items, (e.g. papers, folders, boxes) make it difficult for custodial staff to clean. Dust can be irritating to the eyes, nose and respiratory tract.

A number of display wasp's nests were noted in classroom 9 (see Picture 11). Insect parts can become dried out, aerosolized and may serve as a source of allergenic material for sensitive individuals. Classroom 16 had a build up of chalk dust (see Picture 12). Classroom 17 contained a pipe with damaged fiberglass insulation (see Picture 13). Chalk dust and fiberglass fibers can be sources of eye and respiratory irritation.

Univents are equipped with filters that strain particulates from airflow. The type of filters installed in univents provides minimal filtration of respirable dusts. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed in the univents. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent (Minimum Efficiency Reporting Value equal to 9) would be sufficient to reduce many airborne particulates (Thornburg, D., 2000; MEHRC, 1997; ASHRAE, 1992). Note that increasing filtration can reduce airflow (called pressure drop) which can subsequently reduce the efficiency of the univent due to increased resistance. Prior to any increase of filtration, each univent should be evaluated by a

ventilation engineer to ascertain whether it can maintain function with more efficient filters.

Conclusions/Recommendations

Occupant symptoms and discomfort are consistent with what might be expected in a building with a poorly operating ventilation system. The combination of the building design, maintenance of equipment and the condition of stored materials in the building can contribute to poor indoor air quality. Exhaust ventilation in the building does not function as originally designed. Without adequate exhaust ventilation, normally occurring indoor air pollutants can build up and linger in classrooms. The use of odor or dust generating materials can also serve to exacerbate irritation of eyes, nose and throat in sensitive individuals.

For this reason a two-phase remedial approach is required, consisting of immediate (**short-term**) measures to improve air quality within the school and **long-term** measures that will require planning and resources to adequately address overall indoor air quality concerns.

In view of the findings at the time of this assessment, the following **short-term** recommendations are made:

1. Lock circuit breaker switch box controlling univents to prevent tampering.

2. To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy independent of activation by classroom thermostat control.
3. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room and make univent repairs as needed. Check fresh air intakes for repair and increase the percentage of fresh air intake if necessary.
4. Ensure closet exhaust vents are activated during periods of school occupancy. Inspect exhaust motors and belts periodically for proper function. Repair and replace as necessary.
5. Remove all blockages from univent fresh air diffusers and return vents to facilitate airflow.
6. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all non-porous surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
7. Repair any water leaks and replace any remaining water-stained ceiling tiles. Examine the areas above these tiles for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial as needed.
8. Determine whether peeling paint over the stage contains lead. If paint contains lead the decking and paint coating should be evaluated by a licensed lead paint removal

contractor, and any exposure opportunities should be eliminated through removal or encapsulation.

9. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
10. Seal spaces around classroom sinks to prevent water-damage to interior of cabinets.
11. Move plants away from univents and ensure drip pans are placed underneath plants in classrooms. Examine plants in classrooms for mold growth in water catch basins. Disinfect water catch basins if necessary.
12. Acquire current Material Safety Data Sheets for all products that are used in the building that contain hazardous materials, including office supplies, in conformance with the Massachusetts Right-To-Know Law, M.G.L. c. 111F (MGL, 1983).
13. Store chemicals and cleaning products properly and out of the reach of students.
14. Keep wasp's nest away from univents to prevent the aerosolization of potentially allergenic materials. Consider bringing in items on an "as needed" basis.
15. Clean chalkboards and chalktrays regularly to prevent the build-up of excessive chalk dust.
16. Consider increasing the dust-spot efficiency of HVAC filters. Prior to any increase of filtration, each piece of air handling equipment should be evaluated by a ventilation engineer as to whether it can maintain function with more efficient filters.
17. Encapsulate damaged/exposed fiberglass in classroom 17.

The following **long-term measures** should be considered:

1. Contact an HVAC engineering firm to evaluate unit exhaust ventilators for function. Examine the feasibility of repairing/replacing equipment to restore classroom exhaust ventilation.
2. Consider having an HVAC engineer calibrate univent fresh air control dampers school-wide.
3. Once both the fresh air supply and exhaust ventilation are functioning, the systems should be balanced.

References

ASHRAE. 1992. Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 52.1-1992.

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SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

Schmidt Etkin, D. 1992. Office Furnishings/Equipment & IAQ Health Impacts, Prevention & Mitigation. Cutter Information Corporation, Indoor Air Quality Update, Arlington, MA.

Thornburg, D. 2000. Filter Selection: a Standard Solution. *Engineering Systems* 17:6 pp. 74-80.

Picture 1

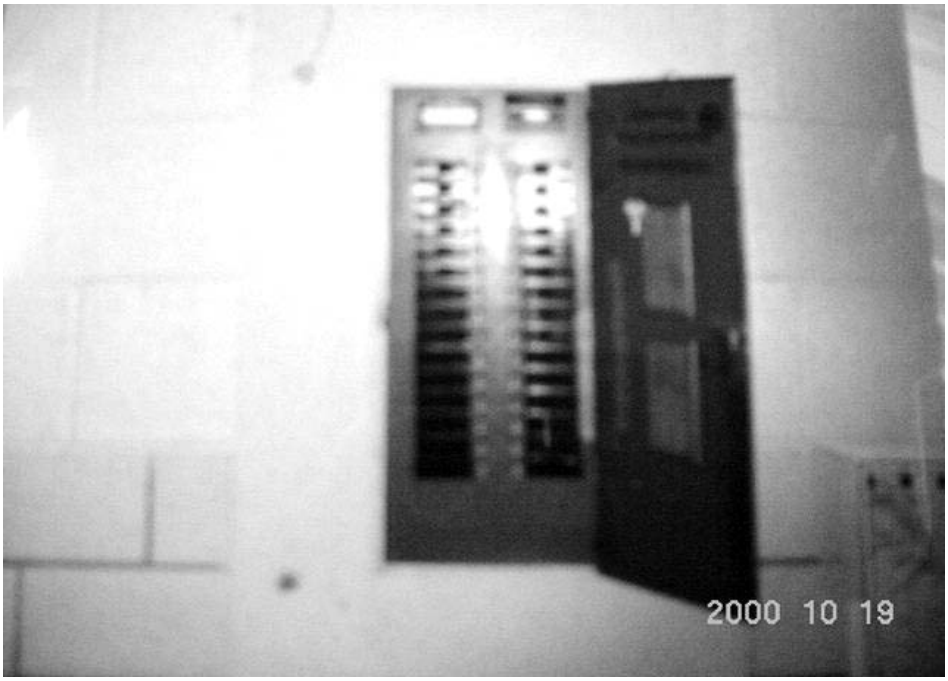
return vent

Classroom Univent Note Materials Obstructing Return Vent along Bottom

Picture 2

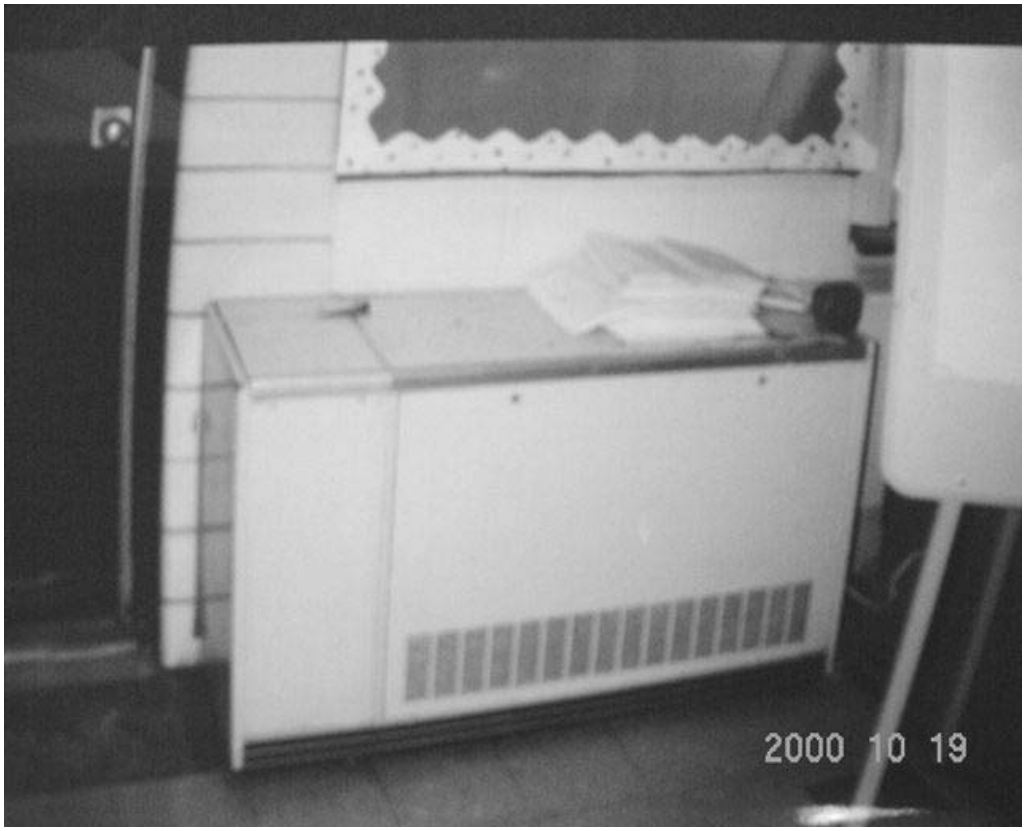
Univent Fresh Air Intake

Picture 3



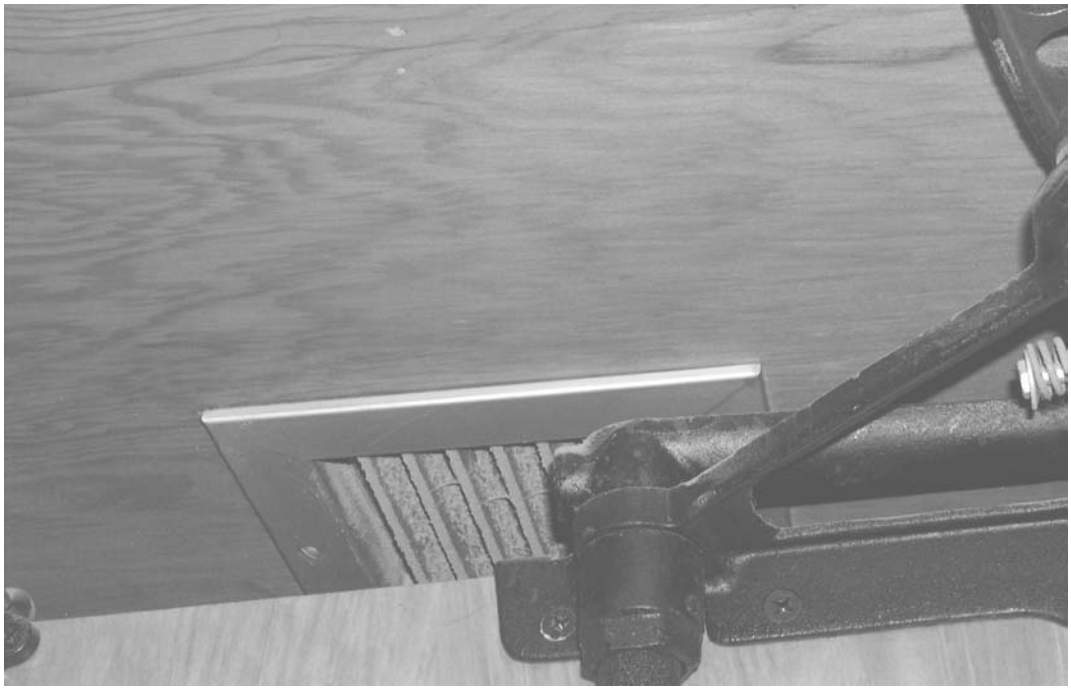
Hallway Electrical Panel Which Control Classroom Univents

Picture 4



Classroom Unit Exhaust Ventilator

Picture 5



Exhaust Vent Located in Classroom Coat Closet

Picture 6

Closet Doors – Undercut to Allow for Exhaust Airflow

Picture 7

Exhaust Vent Located in Computer Room behind Partition

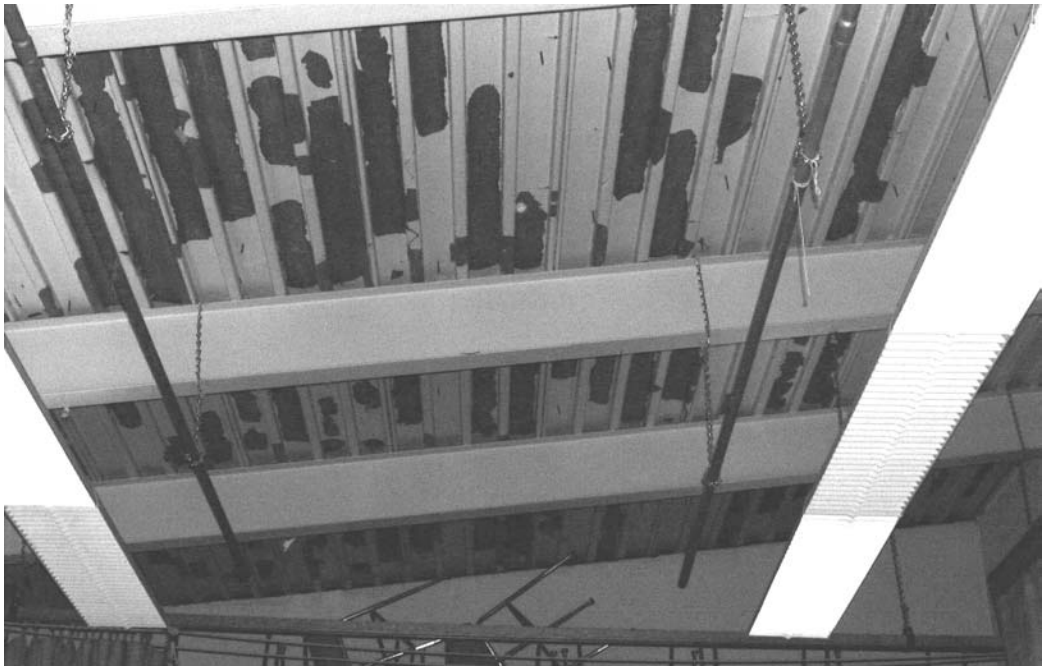
Picture 8

Water Damaged Ceiling Tile

Picture 9

Accumulated Items in a Classroom

Picture 10

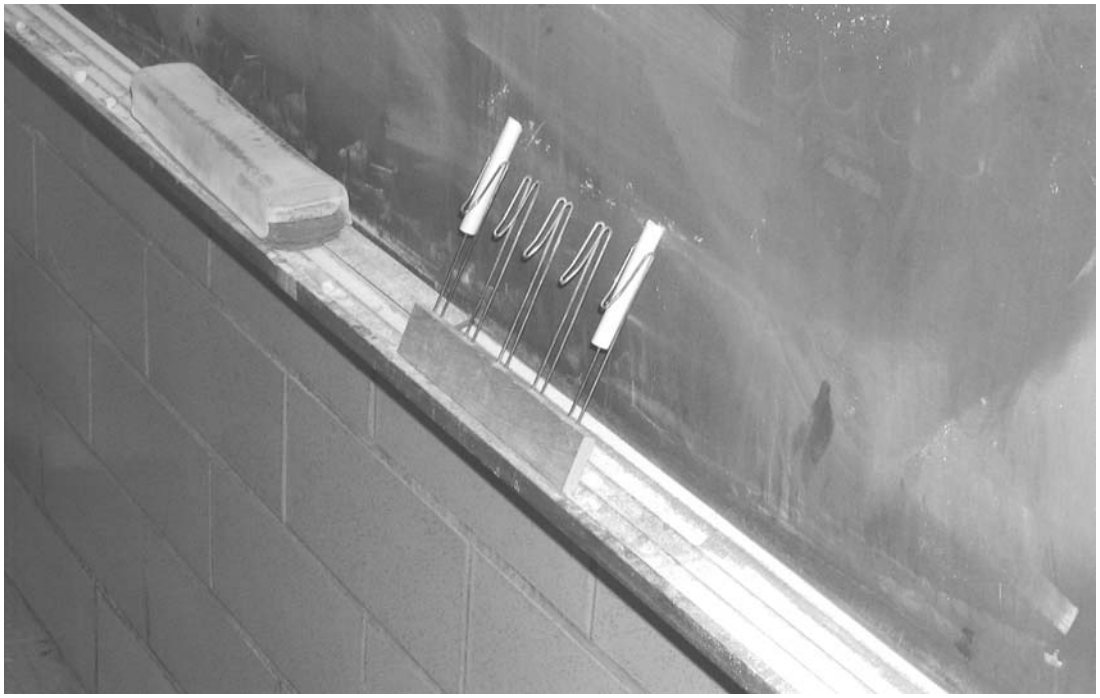


Peeling Ceiling Paint in Cafeteria Stage Area

Picture 11

Inactive Wasps/Hornet's Nests in Classroom

Picture 12



Accumulated Chalk Dust

Picture 13

Damaged/Exposed Fiberglass Pipe Insulation

TABLE 1

Indoor Air Test Results –Lincoln Elementary School, Northboro, MA – October 4, 2000
Morning Testing

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	430	78	37					Weather conditions: clear, sunny 10:00 AM
Classroom 1	449	80	26	2	Yes	Yes	Yes	~20 occupants gone 40 min., Windows and exterior door open, univent off, items on univent diffuser, cleaning product on sink, nail polish remover/ammonia product under sink, spaces between countertop/sink, coat closet exhaust on
Classroom 3	470	74	35	16	Yes	Yes	Yes	Windows and exterior door open, spaces between countertop/sink, isopropyl alcohol under sink, univent blocked-items on diffuser/bookcase in front of return, flowering plant near univent, 4 CT-near windows
Hallway Outside of Room 7								2 CT, 2 aquariums
Classroom 7	403	75	33	2	Yes	Yes	Yes	11 occupants gone 25 min., heat complaints, univent off-items on

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results –Lincoln Elementary School, Northboro, MA – October 4, 2000
Morning Testing

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
								top, windows open
Classroom 8	404	77	31	16	Yes	Yes	Yes	Windows and exterior door open, univent off, spaces between sink/countertop, cleaning product/cardboard/paper materials under sink
Classroom 9	504	80	31	23	Yes	Yes	Yes	Windows and exterior door open, wasp nest display (3), univent off/blocked, heat complaints, spaces around countertop, cleaning product under sink, accumulated materials
Athletic Director's Office	525	79	35	1	No	No	No	Accumulated materials, no ventilation
Gymnasium	520	78	32	0	Yes	Yes	Yes	Supply off, missing ceiling tile
Reading Room (Conference Room)	1026	80	35	8	Yes	No	No	Window open, room used for occupational therapy
Boys Restroom						Yes	Yes	Exhaust on, passive door vent supply

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CT = water-damaged ceiling tiles

Comfort Guidelines

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Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results –Lincoln Elementary School, Northboro, MA – October 4, 2000
Morning Testing

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Men Staff Restroom						Yes	Yes	Exhaust on, passive door vent supply
Classroom 10	830	78	35	4	Yes	Yes	Yes	Univent and exhaust off, window and door open, spaces around sink countertop, cleaning product under sink
Classroom 11	583	77	31	0	Yes	Yes	Yes	Univent and exhaust off, window and doors open, univent return blocked,
Hallway outside classrooms 12 & 13								3 CT
Classroom 13	579	78	29	20	Yes	Yes	Yes	Univent and exhaust off, exterior door open, spaces around sink countertop, cleaning products under sink
Classroom 15	482	77	30	0	Yes	Yes	Yes	Univent and exhaust off, window and exterior door open, cleaning product under sink
Classroom 17	490	77	30	3	Yes	Yes	Yes	Univent and exhaust off, items on univent, window open, exposed fiberglass insulation, 1 CT

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Comfort Guidelines

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Relative Humidity -	40 - 60%

TABLE 4

Indoor Air Test Results –Lincoln Elementary School, Northboro, MA – October 4, 2000
Morning Testing

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Classroom 14	598	78	36	16	Yes	Yes	Yes	Univent blocked, exhaust off, exterior door open, spaces around sink countertop, cleaning product/accumulated items under sink, 3 CT
Classroom 16	788	79	37	18	Yes	Yes	Yes	Univent blocked, exhaust off, window and door open, accumulated items under sink, wall crack, 3 CT, dry erase board, chalk dust, honeycomb
Classroom 18	1202	80	42	16	Yes	Yes	Yes	Univent partially blocked, exhaust off, window open, cleaning product/accumulated items under sink, spaces around countertop, sandbox, 1 CT
Cafeteria	1188	80	43	~200	Yes	Yes		Door open,
Stage Area				0	No	No	No	Utility holes, flaking paint, chalk dust, dry erase board, spaces in ceiling/roof decking

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CT = water-damaged ceiling tiles

Comfort Guidelines

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	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 5

Indoor Air Test Results –Lincoln Elementary School, Northboro, MA – October 4, 2000
Morning Testing

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Teacher's Lounge	846	81	39	8	Yes	No	Yes	Exhaust off, window open, 3 CT, dry erase board
Art Room	755	80	37	18	Yes	Yes	Yes	Window and door open, permanent magic makers
Classroom 2	1023	78	43	21	Yes	Yes	Yes	Univent and exhaust off, univent partially blocked, window open, 2 personal fans-off, dry erase board, 1 CT, plant
Classroom 4	987	78	43	20	Yes	Yes	Yes	Window open, hole in wall under clock, utility holes, 2 CT
Classroom 6	1483	79	41	20	Yes	Yes	Yes	Univent blocked, window open, accumulated items under sink, 4 CT, accumulated items
Supply room					No	No	No	Paper storage, 9 CT, 1 ceiling tile ajar, utility holes, door open
Girl's Restroom					No		Yes	Floor drain, skylight, passive door vent
Library	658	78	39	1	No	Yes	Yes	Exhaust off, dry erase board cleaner, restroom exhaust off-accumulated items, personal fan-on, carpets

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

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	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 6

Indoor Air Test Results –Lincoln Elementary School, Northboro, MA – October 4, 2000
Morning Testing

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Girl's Restroom					No		Yes	Floor drain, skylight, passive door vent, 3 CT, 3 toilets-possibly clogged
Classroom 12	881	79	40	15	Yes	Yes	Yes	Window and exterior door open, cleaners/accumulated items under sink, spaces around countertop, 2 CT, frog/tadpoles/turtle/slug
Counselor's Room (Office Area)	1180	73	40	5	Yes	No	No	Window open, photocopier
Computer Lab-room 25	750	80	37	0	No	Yes	Yes	28 computers, exhaust located in cul de sac, former locker room
Nurse's Office	966	75	41	2	Yes	No	No	
Main Office	944	76	39	1	No	No	No	2 photocopiers

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

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	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 7

Indoor Air Test Results - Lincoln Elementary School, Northboro, MA – October 4, 2000
Afternoon Testing

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	508	73	54					1:45 PM
Classroom 9	1047	84	35	21	Yes	Yes	Yes	Aquarium, door open
Classroom 6	1275	78	47	20				
Library	946	79	43	21	No			Personal fan-on, door open
Classroom 12	1099	79	44	19				
Computer Lab-Room 25	1324	80	48	22	No			Door open, personal fan-on
Classroom 14	1046	79	43	17				Door open
Classroom 16	998	80	42	18				Door open
Classroom 18	1284	80	45	16				
Stage Area	1310	79	44	20				

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

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	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 8

Indoor Air Test Results - Lincoln Elementary School, Northboro, MA – October 4, 2000
Afternoon Testing

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Teacher's Lounge	1067	81	43	0				
Art Room	1201	80	45	20				Exhaust on
Classroom 2	1699	77	54	21				
Classroom 4	1407	78	51	0				
Classroom 17	726	83	35	4				
Classroom 7	1012	81	38	20				
Classroom 8	1060	82	39	22				
Classroom 1	820	82	36	21				Occupants in classroom ~10 minutes prior to dismissal
Classroom 5	1100	78	50	12				
Classroom 3	1120	80	36	22				Bleach on countertop, latex rubber

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 9

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Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Team Room (lower wing)	936	82	38	0				Exhaust activated by wall switch-off, lamination machine
Classroom 10	1400	80	43	19				
Classroom 11	1420	80	39	18				
Classroom 13	1100	79	43	1				
Classroom 15	1240	82	38	19				

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Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%